Airport Capacity Enhancement Terminal Airspace Study

San Bernardino International Airport

Norton Air Force Base Reuse Study

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May 1994

Prepared jointly by the U.S. Department of Transportation, Federal Aviation Administration, the San Bernardino International Airport Authority, and the representatives of airlines serving the Ontario and San Bernardino areas.

Table of Contents

INTRODUCTION

Objective

This study was initiated by the San Bernardino International Airport Authority and the Federal Aviation Administration (FAA) to evaluate the impact of introducing scheduled commercial air service at San Bernardino International Airport (SBD) on existing air traffic operations in the surrounding airspace, particularly at nearby Ontario International Airport (ONT). The study examined the airspace interactions between arrivals and departures at SBD and the airspace interactions between SBD and ONT.

Background

Since 1985, the FAA has sponsored Airport Capacity Design Teams at airports across the country affected by delay. Representatives from airport operators, air carriers, other airport users, and aviation industry groups have worked together with FAA representatives to identify and analyze capacity problems at each individual airport and recommend improvements that have the potential for reducing delays. The improvements recommended by the Capacity Teams have emphasized construction of new runways and taxiways, installation of enhanced facilities and equipment, and changes in air traffic control procedures.

When an Airport Capacity Design Team study is completed, an airport has a recommended plan of action to increase its capacity. But, this plan will do little good if the airspace in the vicinity of the airport cannot handle the increased traffic. For this reason, the FAA's Office of System Capacity and Requirements (ASC) has been developing a program of Airspace Capacity Design Team studies of the terminal and en route airspace associated with delay-problem airports across the country. These studies are normally intended to follow Airport Capacity Design Team studies. In the case of San Bernardino International Airport, however, an entirely new airport, capable of supporting the full range of passenger and cargo air service, is now open, with the potential to increase the overall capacity of the regional airport system.

The San Bernardino International Airport Authority was created in April 1992 to own, operate, and develop the airport portion of Norton Air Force Base (AFB). Norton AFB appeared on the Department of Defense Base Closure List in 1989. The local community began planning for the reuse of the facility at that time. With the recent signing of a lease between the Air Force and the Airport Authority, San Bernardino International Airport was opened.

San Bernardino International Airport consists of 1,300 acres, which include numerous commercial and industrial sites and a 10,000 foot, precision approach runway. Lockheed Commercial Aircraft Center conducts maintenance inspections and overhauls on widebody jets and recently invested $30 million in their facility on the Airport. The Airport Authority is in the process of negotiating with commercial passenger and freight carriers to begin scheduled air service. The Airport Authority is also negotiating with several corporations to establish cargo hubs that will link air freight activities to truck and rail transportation.

The San Bernardino International Airport was recently included in the Military Airports Program (MAP). The MAP provides funding to former military bases through FAA grants for airport related improvements. Through this program, the Airport Authority is eligible for $20 million in grant funds over the next five years. The Airport Authority is currently in the process of developing a $16 million terminal and roadway project that will improve the existing terminal and facilitate airport access to the vast interstate highway network serving the area.

The San Bernardino International Airport Authority is moving closer to establishing commercial air service. Realizing this new service will have some impact on the existing air traffic system in the area, the Airport Authority asked the FAA to conduct an Airspace Capacity Design Team study to determine the effect that air carrier operations at SBD would have on airspace operations in the vicinity, particularly at nearby Ontario International Airport. In addition, the Airport Authority asked the FAA to examine alternatives to determine the best operating procedures to maximize the benefits of commercial service at SBD.

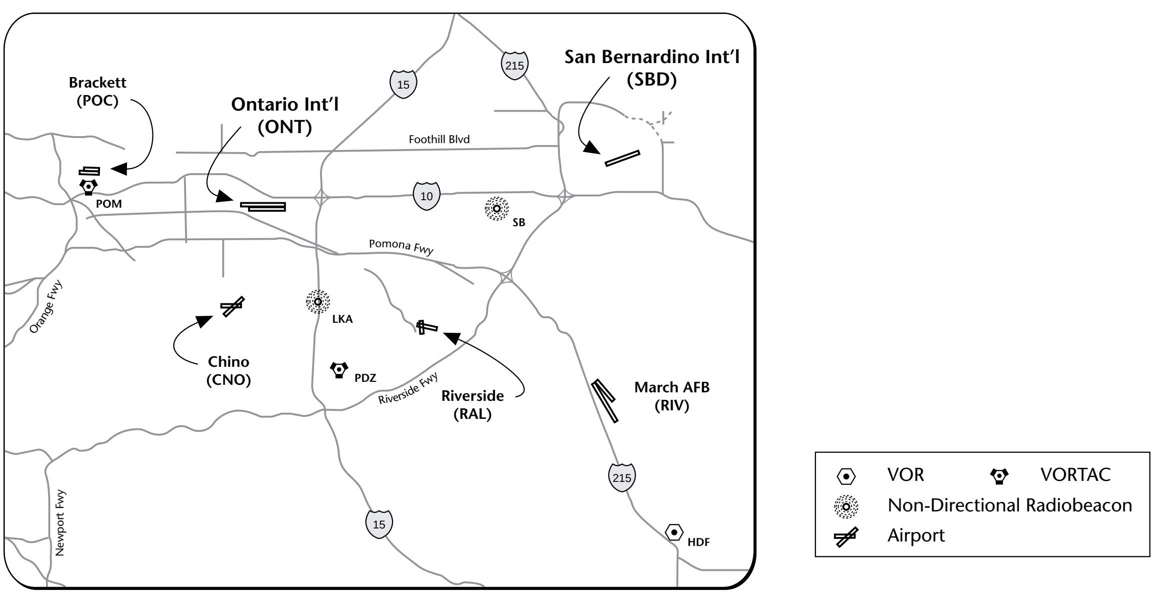
Scope

The Airspace Capacity Team limited its analysis to aircraft activity within the terminal area and on the airfield. The team considered the technical and operational feasibility of proposed improvements, but did not address environmental and design issues or the cost of development and construction. They also did not consider the additional workload and traffic complexity for the controller. These issues need to be addressed in future airport and airspace planning studies, and the data generated in this study can be used in these follow-on studies.

Methodology

The Airspace Capacity Team, which included representatives from the FAA, the San Bernardino International Airport Authority, the U.S. Air Force, and various aviation industry groups (see Appendix A), met periodically for review and coordination. The team considered various operational and airfield facility development options proposed by the members of the team. Alternatives that were considered practicable were developed into experiments that could be tested by simulation modeling. The FAA Technical Center's Aviation Capacity Branch provided expertise in airport simulation modeling. The team validated the data used as input for the simulation modeling and analysis and reviewed the interpretation of the simulation results. The data, assumptions, alternatives, and experiments were continually reevaluated, and modified where necessary, as the study progressed. Data inputs used in the simulation modeling can be found in Appendix B.

Initial work consisted of gathering data and formulating assumptions required for the capacity and delay analysis and modeling. Where possible, assumptions were based on actual field observations at San Bernardino International Airport and Ontario International Airport. Improvements proposed by the Airspace Design Team were analyzed in relation to current and future demands with the help of a computer model, the Airport and Airspace Simulation Model (SIMMOD). Appendix C briefly explains the model.



Study Results

Figure 1. San Bernardino International Airport

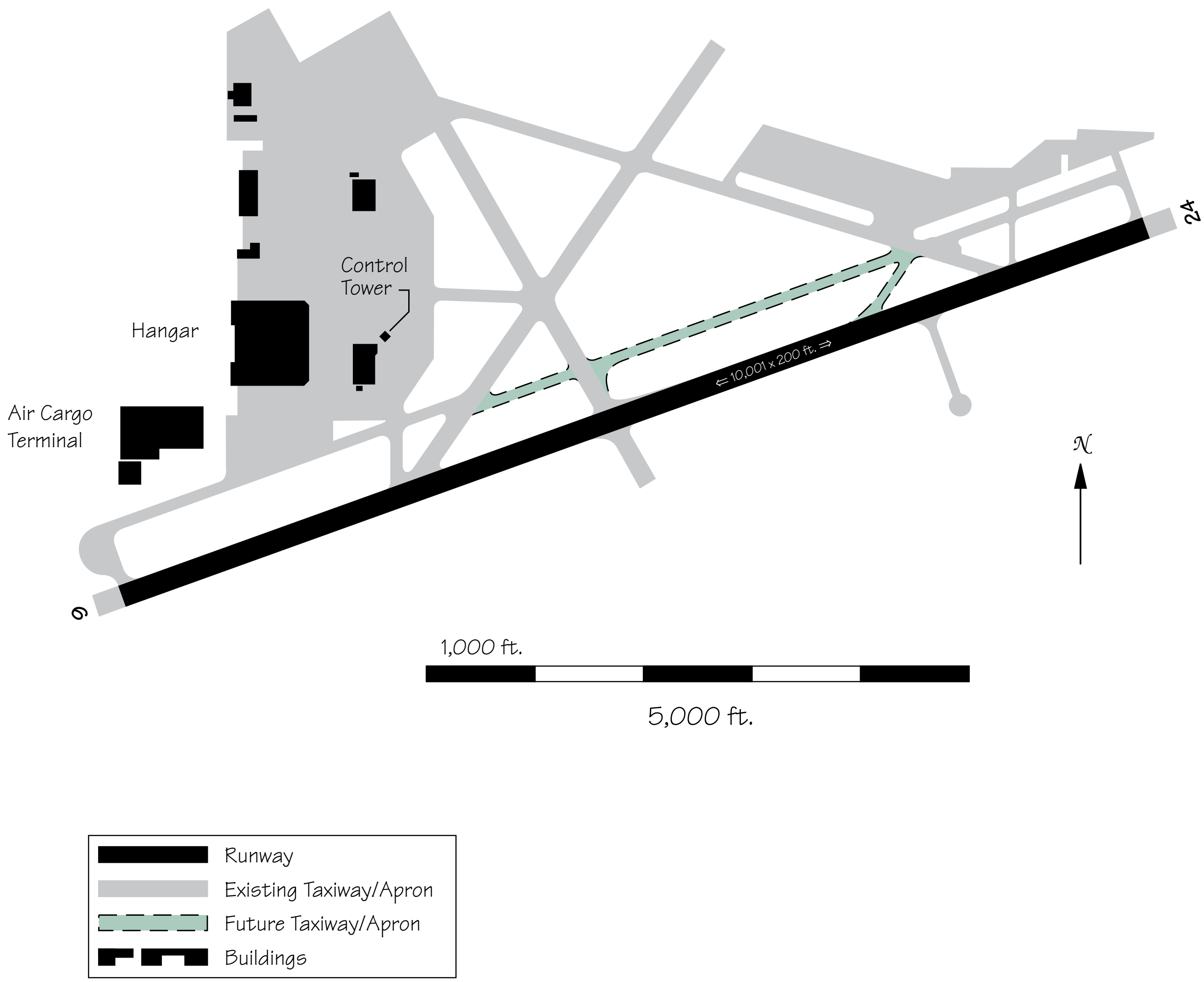
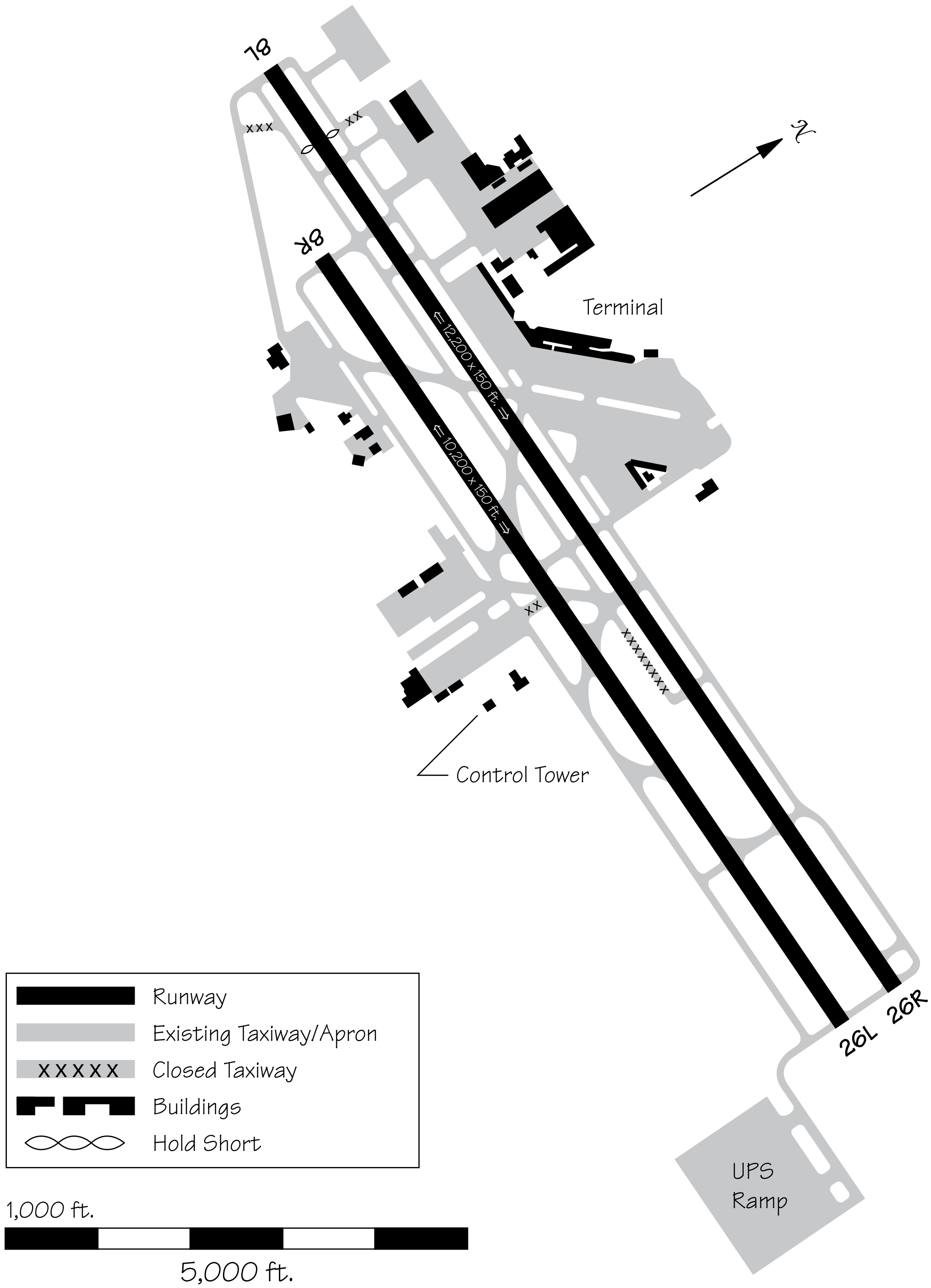


Figure 2. Ontario International Airport



Background

The purpose of the study was to determine the amount of delay the air traffic control (ATC) system would encounter with the introduction of scheduled air carrier service at SBD. The FAA Technical Center used the Airport and Airspace Simulation Model (SIMMOD) in conducting the study. SIMMOD analyzed the airspace interactions between arrivals and departures at SBD and the airspace interactions between SBD and ONT.

Figure 1 shows the current layout of the San Bernardino International Airport, and Figure 2, Ontario International Airport. In studying the airspace over SBD and its interaction with the airspace over ONT, the Airspace Capacity Design Team evaluated four runway configurations, which are shown in Figure 11.

Two of the runway configurations result in aircraft operating in a head-to-head flow at SBD, and two result in aircraft operating in an east flow at SBD. In a head-to-head flow, aircraft arrive at SBD heading east (Runway 6) and depart heading west (Runway 24). In an east flow, aircraft arrive and depart heading east (Runway 6). The study only analyzed east approaches to Runway 6 at SBD because only that runway has the instrument landing system (ILS) necessary to support instrument approaches. Figures 12 through 15 illustrate the arrival and departure routes for SBD and ONT for each configuration.

In SBD's Capital Improvement Program, one of the first major improvements will be to complete a taxiway parallel to the runway and a high speed exit off Runway 6. Accordingly, the study analyzed both the present taxiway system and the proposed taxiway system. In addition, the study compared the effects of adding new aircraft traffic from SBD to the ATC system to the effects of moving aircraft traffic to SBD from ONT, i.e., adding no new aircraft to the system. Finally, the study calculated the results for each of three different time frames.

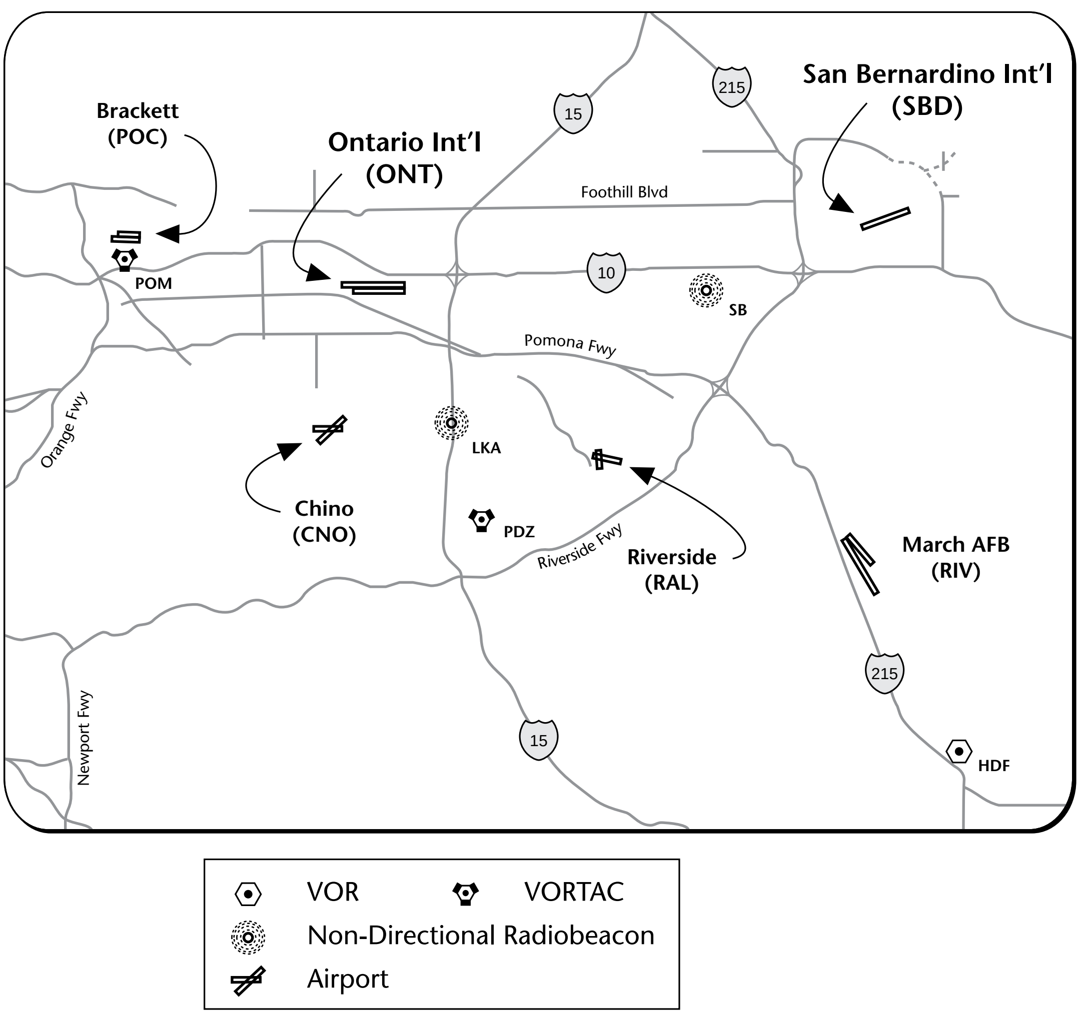
- Baseline—SBD's initial operation with start-up of scheduled air carrier service in 1994.
- Future 1—Five years down the planning horizon, or 1999.
- Future 2—Five additional years down the planning horizon, or 2004.

Study results are presented for each of the arrival and departure flows, the Head-to-Head Flow and the East Flow, under four scenarios.

- SBD with the present taxiway system and adding aircraft to the ATC system.
- SBD with the present taxiway system and moving aircraft from ONT to SBD.
- SBD with the future taxiway system and adding aircraft to the ATC system.
- SBD with the future taxiway system and moving aircraft from ONT to SBD.

By way of summary, with SBD conducting flight operations in a head-to-head flow, the system costs at the Baseline and Future 1 demand levels when both SBD and ONT are operating are fairly equal to the costs when ONT is operating alone. However, at Future 2 demand levels, the system costs are greater with both SBD and ONT operating than with ONT operating alone. This is due primarily to the greater number of departures at Future 2 not being able to take off immediately, because the requirements for separation between departures and arrivals are so much greater for the head-to-head operation at SBD.

With SBD conducting flight operations in an east flow, the systems costs at the Baseline and Future 1 demand levels when both SBD and ONT are operating are again fairly equal to the costs when ONT is operating alone. At Future 2 demand levels, however, the system costs are actually less with both SBD and ONT operating. This highlights the fact that an east-flow operation at SBD is much more efficient and that the addition of SBD as an air carrier airport will actually reduce system delays and increase the capacity of the air traffic system in the area.



Head-to-Head Flow

For two of the runway configurations analyzed in the study, aircraft at SBD operate in a head-to-head flow. In a head-to-head flow, aircraft arrive at SBD heading east (Runway 6) and depart heading west (Runway 24). The study examined the effects of the present taxiway system at SBD and the effects of the proposed taxiway system. The study also evaluated the effects of adding new aircraft traffic from SBD to the ATC system to the effects of moving aircraft traffic to SBD from ONT, i.e., adding no new aircraft to the system. This produced four different scenarios, and the results for each of these scenarios are summarized below.

Figures 3 and Figure 4 illustrate how annual delay costs will continue to grow at ONT as demand increases if there are no improvements made in airfield capacity and commercial air service is provided only from ONT, i.e., the *Do Nothing* scenario. They also show the annualized system delay costs with both ONT and SBD providing commercial air service.

For the Baseline and Future 1 demand levels, the system costs when using SBD and ONT or when using ONT only are fairly equal. But, at Future 2 demand levels, the system costs when using SBD and ONT are greater than using ONT only. This is due mainly to the greater number of departures not being able to take off because the requirements for departure/arrival separation are so great for a head-to-head operation.

Figure 5 shows the system penalties and savings in annual delay costs that would result from conducting flight operations at both SBD and ONT, with SBD operating in a head-to-head flow, when compared to conducting flight operations at ONT only.

Present Taxiway System—Adding Aircraft

With the present taxiway system at SBD and with the additional aircraft at SBD added to the ATC system, the impact on the system in terms of delay costs is minimal at Baseline and Future 1 demand levels. But, at Future 2 demand levels, the cost of using this alternative is considerable. The head-to-head operation at SBD chokes departures there and results in very large delays. The spacing of arrivals required at SBD to allow departures to take off more quickly would affect arrivals at ONT.

When compared to the anticipated delay costs of providing commercial air service only from Ontario International Airport, there would be an annual delay cost penalty of $0.53 million at the Baseline level of operations, $1.14 million at Future 1, and $29.38 million at Future 2.

Present Taxiway System—Moving Aircraft

With the present taxiway system at SBD, moving aircraft from ONT to SBD rather than adding additional aircraft to the ATC system results in somewhat lower costs at the Baseline and Future 1 demand levels. At Future 2 demand levels, the head-to-head operation at SBD again results in large delay costs.

When compared to the anticipated delay costs of providing commercial air service only from Ontario International Airport, there would be an annual savings in delay cost of $6.56 million at the Baseline level of operations and $6.78 million at Future 1. At Future 2 there would be an annual delay cost penalty of $7.73 million.

Future Taxiway System—Adding Aircraft

With the proposed new parallel taxiway and high-speed exit operational at SBD, the delay-cost impact of the additional aircraft at SBD being added to the ATC system is somewhat less at the Baseline and Future 1 demand levels than with the present taxiway system. At Future 2 demand levels, the delay costs remain high.

When compared to the anticipated delay costs of providing commercial air service only from Ontario International Airport, there would be an annual delay cost penalty of $0.26 million at the Baseline level of operations, $0.10 million at Future 1, and $21.51 million at Future 2.

Future Taxiway System—Moving Aircraft

With aircraft operations moved from ONT to SBD and the proposed new taxiway and exit system at SBD operational, the savings in delay costs at the Baseline and Future 1 demand levels are somewhat greater than with the present taxiway system. At Future 2 levels, the head-to-head operation again results in a delay-cost penalty.

When compared to the anticipated delay costs of providing commercial air service only from Ontario International Airport, there would be an annual delay cost savings of $6.90 million at the Baseline level of operations and $7.92 million at Future 1. At Future 2 there would be an annual delay cost penalty of $2.92 million.

Figure 3. Annual Delay Costs—Head-to-Head Flow

	Estimated Annual Delay Costs (millions 1992 $) Baseline	Future 1	Future 2
1. ONT operating alone—Do Nothing	$101.43	$127.21	$166.50
2. Present taxiway system—adding aircraft	$101.96	$128.35	$195.88
3. Present taxiway system—moving aircraft	$94.87	$120.43	$174.22
4. Future taxiway system—adding aircraft	$101.69	$127.31	$188.00
5. Future taxiway system—moving aircraft	$94.53	$119.29	$169.41

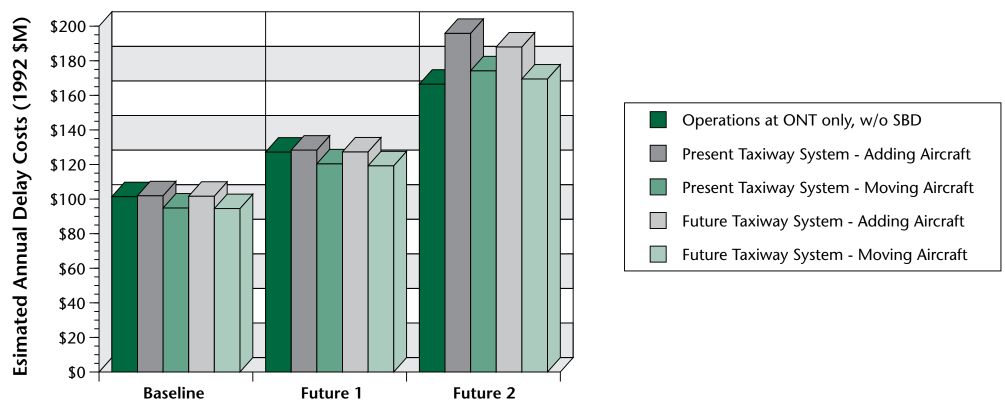


Figure 4. Comparison of Annual Delay Costs—Head-to-Head Flow

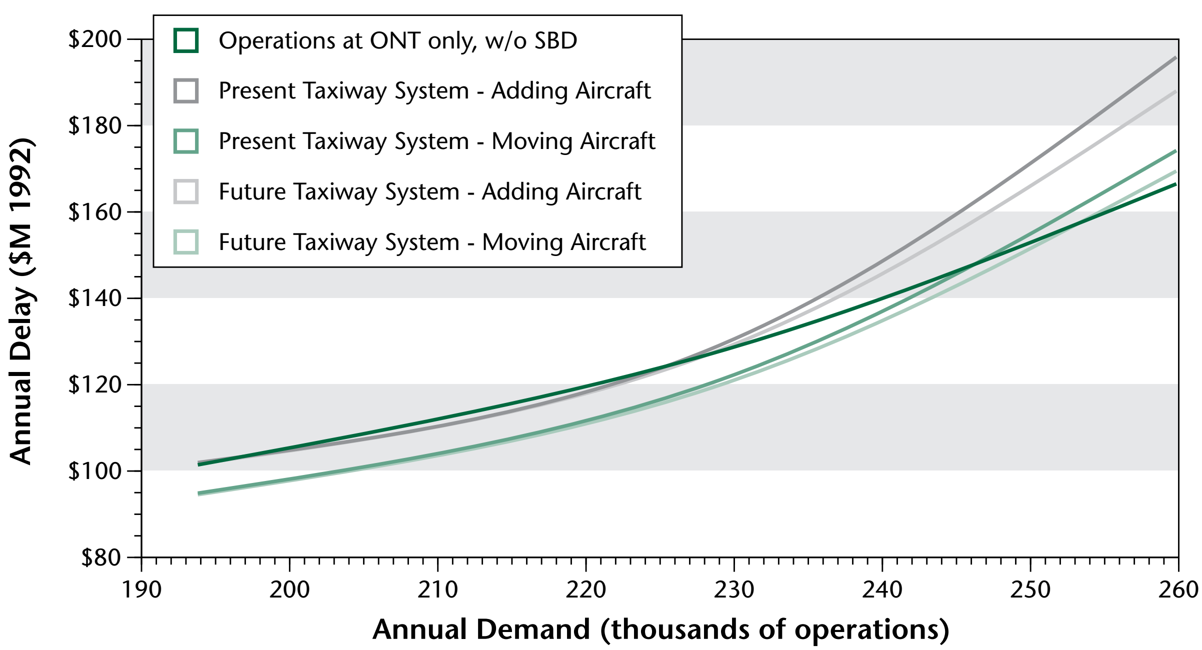
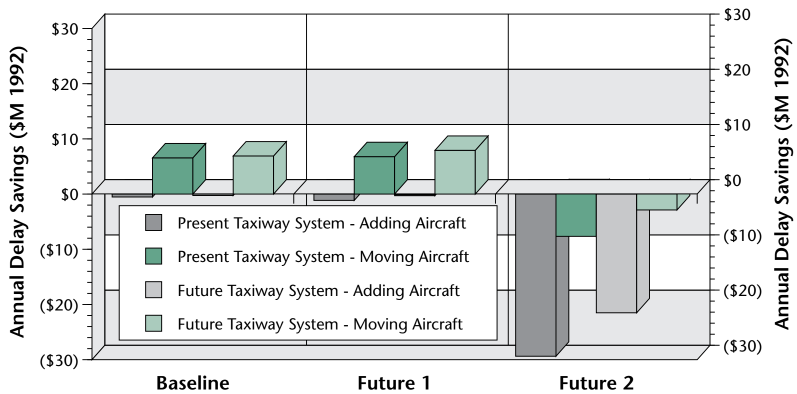


Figure 5. Annual Delay Cost Penalties and Savings—Head-to-Head Flow

	Estimated Annual Delay Savings (millions 1992 $)		
	Baseline	Future 1	Future 2
1. Present taxiway system—adding aircraft	($0.53)	($1.14)	($29.38)
2. Present taxiway system—moving aircraft	$6.56	$6.78	($7.73)
3. Future taxiway system—adding aircraft	($0.26)	($0.10)	($21.51)
4. Future taxiway system—moving aircraft	$6.90	$7.92	($2.92)



East Flow

For two of the runway configurations analyzed in the study, aircraft at SBD operate in an east flow. In an east flow, aircraft arrive and depart heading east (Runway 6). The study again examined the effects of the present taxiway system at SBD and the effects of the proposed taxiway system. The study also examined the effects of adding new aircraft traffic from SBD to the ATC system and the effects of moving aircraft traffic to SBD from ONT, i.e., adding no new aircraft to the system. This produced four different scenarios, and the results for each of these scenarios are summarized below.

Figures 6 and Figure 7 illustrate how annual delay costs will continue to grow at ONT as demand increases if there are no improvements made in airfield capacity and commercial air service is provided only from ONT, i.e., the *Do Nothing* scenario. They also show the annualized system delay costs with both ONT and SBD providing commercial air service.

Again, for the Baseline and Future 1 demand levels, the system costs when using SBD and ONT or when using ONT only are fairly equal. But, at Future 2 demand levels, the system costs when using SBD and ONT are less than using ONT only. This highlights the fact that the east-flow operation is more efficient and will actually reduce system delays and increase the capacity of the air traffic system in the area.

Figure 8 shows the system savings in annual delay costs that would result from conducting flight operations at both SBD and ONT, with SBD operating in an east flow, when compared to conducting flight operations at ONT only.

Present Taxiway System—Adding Aircraft

With the present taxiway system at SBD and with the additional aircraft at SBD added to the ATC system, the savings in delay costs at the Baseline demand level would be minimal, with a slight improvement at Future 1. At the Future 2 demand level, the savings would be much greater, mainly because the departure flow is to the east, the same as the arrival flow, which decreases the requirement for departure/arrival separation.

When compared to the anticipated delay costs of providing commercial air service only from Ontario International Airport, there would be an annual delay cost savings of $0.62 million at the Baseline level of operations, $0.77 million at Future 1, and $21.22 at Future 2.

Present Taxiway System—Moving Aircraft

With aircraft operations moved from ONT to SBD, the existing system will show a greater delay savings benefit at all demand levels because there is no increase in traffic to the system as a whole.

When compared to the anticipated delay costs of providing commercial air service only from Ontario International Airport, there would be an annual delay cost savings of $6.37 million at the Baseline level of operations, $13.12 million at Future 1, and $28.87 million at Future 2.

Future Taxiway System—Adding Aircraft

With the proposed new parallel taxiway and high-speed exit operational at SBD, the savings in delay costs are slightly higher than with the existing airfield system. The improved flow of ground traffic, particularly on the taxiways, would relieve taxiway interference and delays.

When compared to the anticipated delay costs of providing commercial air service only from Ontario International Airport, there would be an annual delay cost savings of $1.01 million at the Baseline level of operations, $5.15 million at Future 1, and $21.86 million at Future 2.

Future Taxiway System—Moving Aircraft

With aircraft operations moved from ONT to SBD and the proposed new taxiway and exit system at SBD operational, the delay savings increased at all demand levels.

When compared to the anticipated delay costs of providing commercial air service only from Ontario International Airport, there would be an annual delay cost savings of $7.75 million at the Baseline level of operations, $12.81 million at Future 1, and $29.74 million at Future 2.

Figure 6. Annual Delay Costs—East Flow

	Estimated Annual Delay Costs (millions 1992 $) Baseline	Future 1	Future 2
1. ONT operating alone—Do Nothing	$101.43	$127.21	$166.50
2. Present taxiway system—adding aircraft	$100.82	$126.44	$145.28
3. Present taxiway system—moving aircraft	$95.07	$114.09	$137.62
4. Future taxiway system—adding aircraft	$100.43	$122.06	$144.64
5. Future taxiway system—moving aircraft	$93.68	$114.40	$136.76

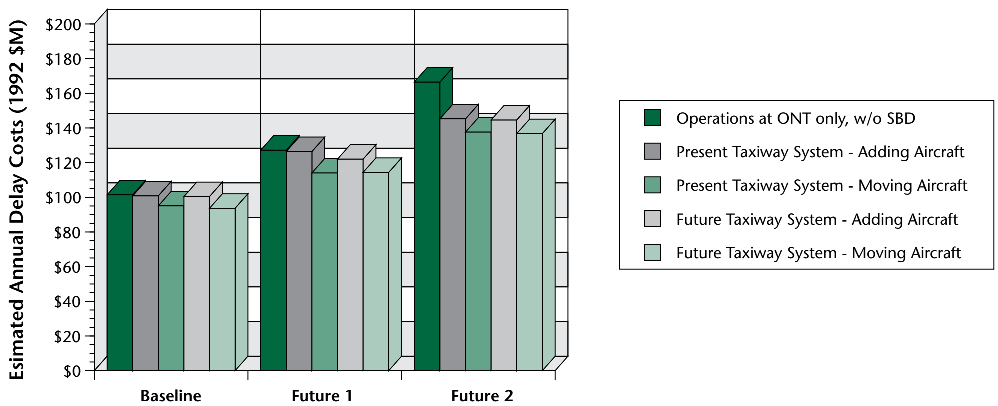


Figure 7. Comparison of Annual Delay Costs—East Flow

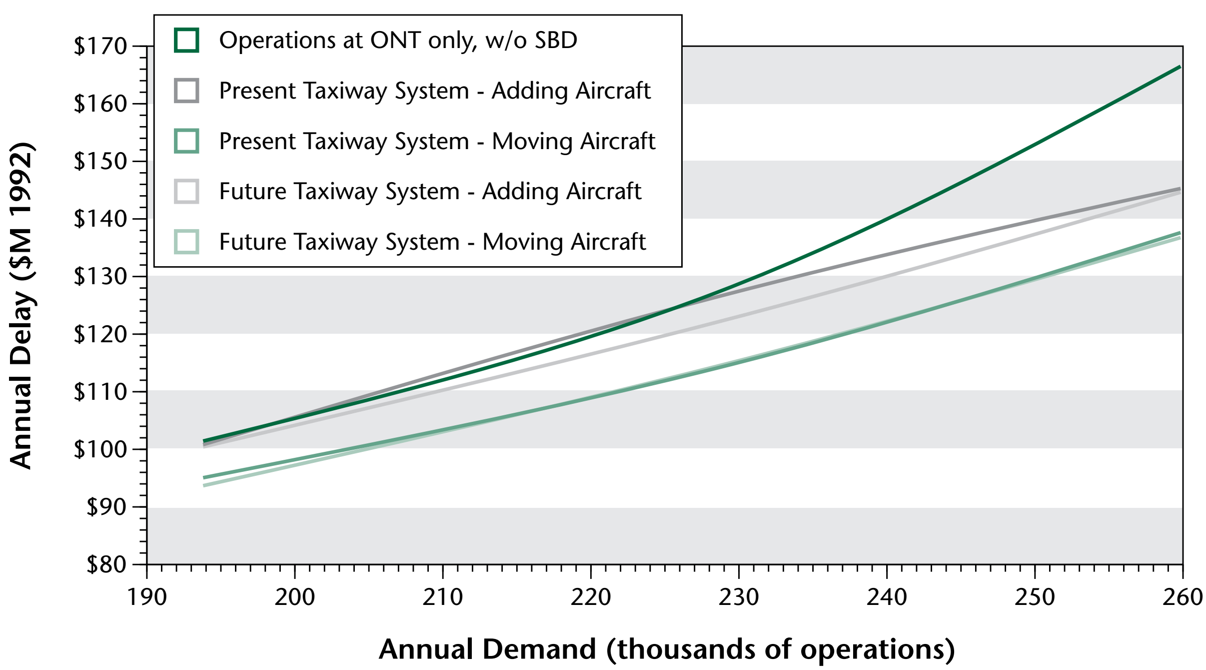
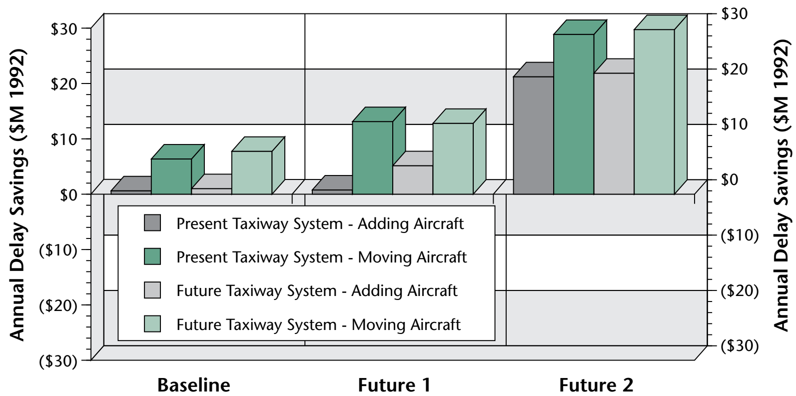


Figure 8. Annual Delay Cost Savings—East Flow

	Estimated Annual Delay Savings (millions 1992 $) Baseline	Future 1	Future 2
1. Present taxiway system—adding aircraft	$0.62	$0.77	$21.22
2. Present taxiway system—moving aircraft	$6.37	$13.12	$28.87
3. Future taxiway system—adding aircraft	$1.01	$5.15	$21.86
4. Future taxiway system—moving aircraft	$7.75	$12.81	$29.74



Appendix A

Participants

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Appendix B

Data Inputs

The San Bernardino International Airport Airspace Capacity Design Team evaluated the effects that scheduled air carrier operations there would have on airspace operations in the vicinity, particularly at Ontario International Airport. Figure 9 provides the airfield weather conditions used for the computer model simulations for visual meteorological conditions (VMC) and instrument meteorological conditions (IMC).

Figures 10 shows the runway utilization percentages used in the study for these conditions for each of four runway configurations. The study took into account four different arrival and departure configurations which can occur between SBD and ONT. Configurations 1 and 2 result in aircraft operating in a head-to-head flow (H2H) at SBD. In a head-to-head flow, aircraft arrive at SBD heading east (Runway 6) and depart heading west (Runway 24). Configurations 3 and 4 result in aircraft operating in an east flow at SBD. In an east flow, aircraft at SBD arrive and depart heading east (Runway 6). The study analyzed only the east approaches to Runway 6 at SBD, because only that runway has the ILS equipment necessary to support instrument approaches.

Figure 11 illustrates these runway configurations. Figures 12 through 15 illustrate the arrival and departure routes for SBD and ONT for each configuration.

Daily operations corresponding to an average day in the peak month were used for each of the forecast periods. Daily delays were annualized to measure the potential economic benefits. The annualized delays provide a basis for comparing the benefits of the proposed changes.

Air traffic destined for SBD and ONT must be handled and directed by the Ontario Terminal Radar Approach Control (TRACON). Arrivals to the Ontario TRACON occur through six air traffic control fixes. Figure 16 illustrates the percentage of aircraft arriving at SBD and ONT using the fixes shown. The arrivals enter the TRACON area spaced 10 miles apart, then decrease this separation through the common approach fix, PETIS. According to the study, when both SBD and ONT are in an easterly flow, the amount of separation can be decreased.

Configuration 4, with arrivals and departures to the east at both SBD and ONT, is the most efficient and beneficial configuration for both airports.

Departures out of the TRACON also occur through six fixes. Figure 16 illustrates the percentage of aircraft departing from SBD and ONT using the fixes shown. The departures must be spaced at 10 or 20 miles depending on the fix before they can exit the TRACON area. These restrictions were applied to both SBD and ONT in the study.

Figure 17 illustrates the daily and annual operations levels for the Baseline, Future 1, and Future 2 for two cases, one with aircraft operations from SBD added to the system totals, the other with aircraft operations moved from ONT to SBD without adding to system totals. Figure 18 shows the hourly profile of daily demand for SBD for the Baseline, Future 1, and Future 2 activity levels. Figure 19 shows the hourly profile of daily demand for ONT for the present level of activity, which was used for all three demand levels.

The present demand schedule depicts actual field data. The data collected provided the airline, aircraft class and type, runway used, gate used, and the scheduled time. The future demand schedule was based on a forecast total of daily operations provided by the San Bernardino International Airport Authority.

Figure 20 provides a description of the aircraft classes used in the study. Figure 21 provides a breakdown of the aircraft fleet mix by class used for ONT for all demand levels and for SBD and the total system (SBD and ONT) for Baseline, Future 1, and Future 2.

Figure 22 provides a breakdown of the fleet mix by aircraft category for SBD, ONT, and the total system. The aircraft fleet mix by category was used in calculating the aircraft direct operating costs at SBD and ONT.

Aircraft operational cost information for scheduled operations was developed from the AVMARK Incorporated *Quarterly Aircraft Operating Costs and Statistics,* Second Quarter, 1992. The costs are based on various types of aircraft and airline specific total operation cost values whenever feasible. Aircraft operational cost information for non-scheduled operations was developed from data available from Aviation Data Service and updated with costs from the FAA's Aviation Forecasting Branch.

The aircraft direct operating costs at SBD and ONT were calculated by weighted costs, depending on the type and number of aircraft in each aircraft category, and then grouped according to category. Figure 23 shows the results of these calculations. These results represent the costs for operating the aircraft and include fuel, maintenance, crew costs, and the like, but they do not consider such items as lost passenger time or disruption to airline schedules.

Figure 9. Airfield Weather

Ceiling/Visibility		Occurrence
VMC	1,500 ft. and above/3 mi and above	84%
IMC	Below 1,500 ft./below 3 mi	16%

Figure 10. Runway Utilization

Configuration	Arrival and Departure Flow	VMC	IMC
1	ONT-West Flow/SBD-Head-to-Head Flow	70%	13%
2	ONT-East Flow/SBD-Head-to-Head Flow	14%	3%
3	ONT-West Flow/SBD-East Flow	70%	13%
4	ONT-East Flow/SBD-East Flow	14%	3%

Figure 11. Runway Configurations and Percentage Use

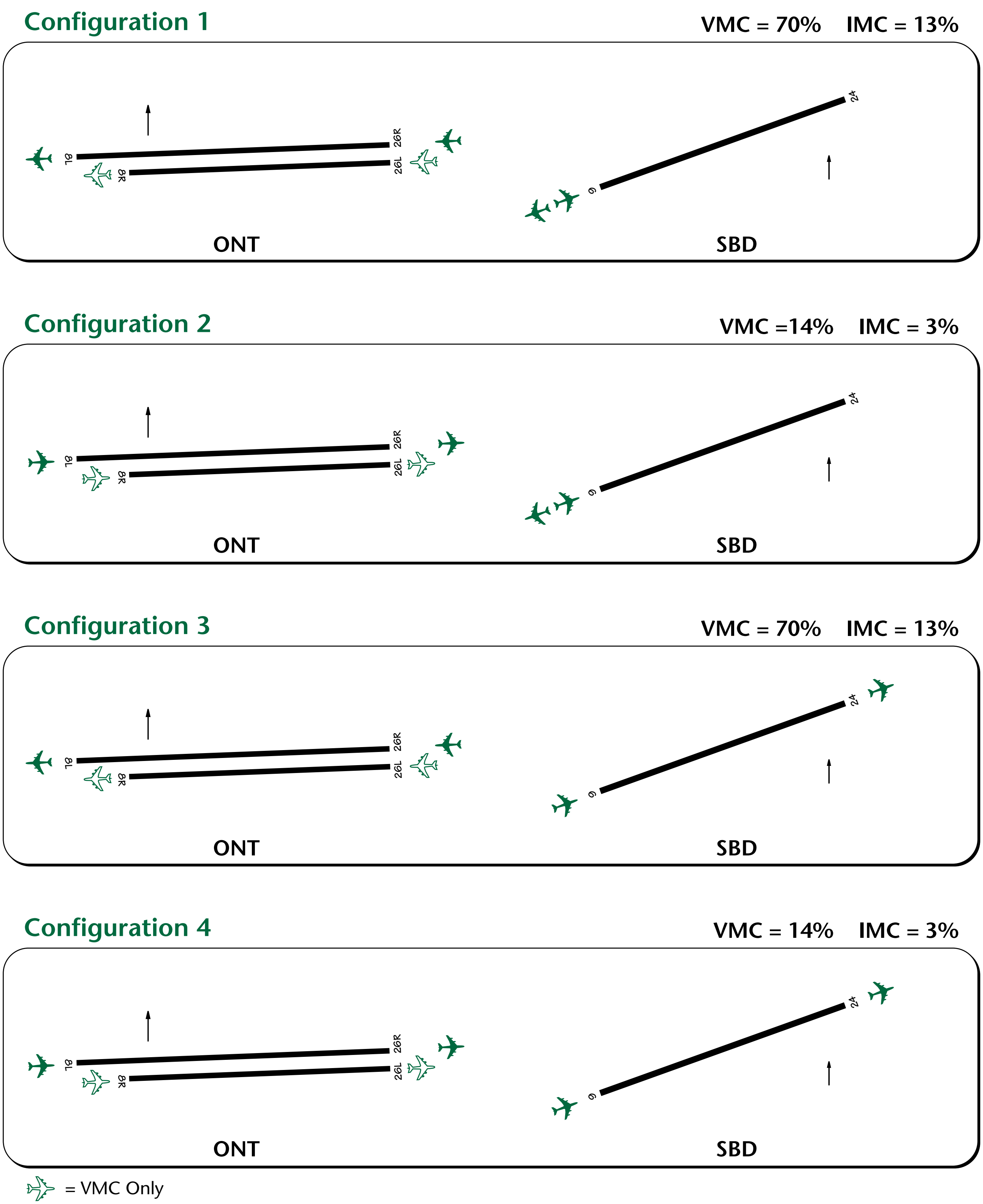
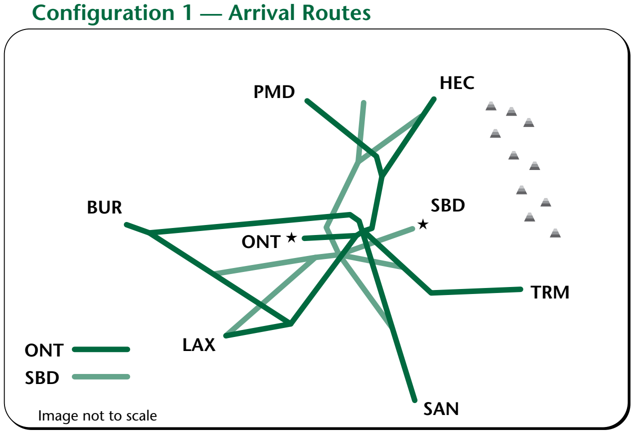


Figure 12. Configuration 1 Arrival and Departure Routes

Configuration 1 — Arrival Routes



Configuration 1 — Departure Routes

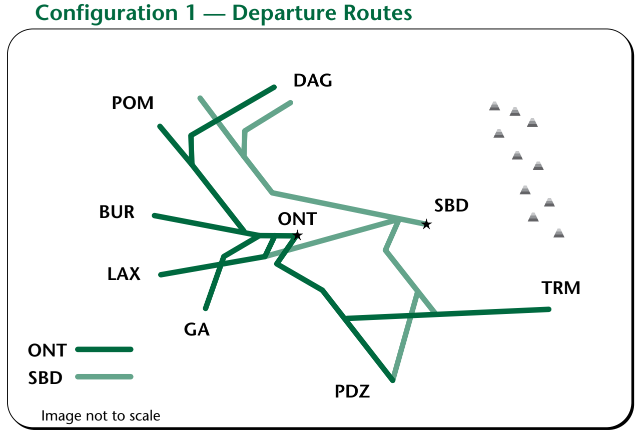
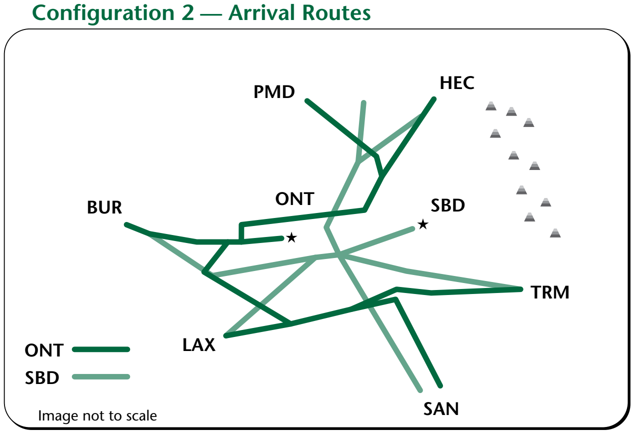


Figure 13. Configuration 2 Arrival and Departure Routes

Configuration 2 — Arrival Routes



Configuration 2 — Departure Routes

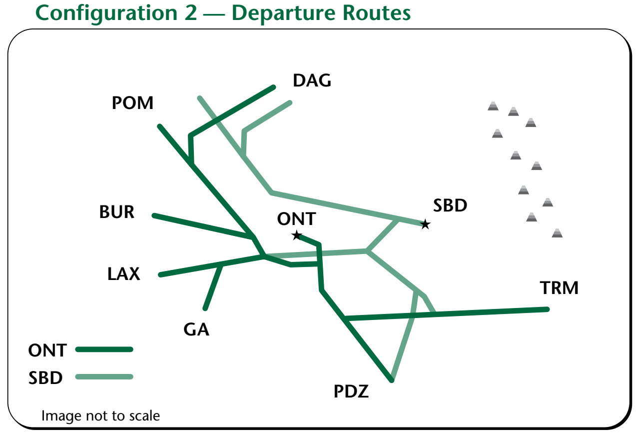


Figure 14. Configuration 3 Arrival and Departure Routes

Configuration 3 — Arrival Routes Configuration 3 — Departure Routes

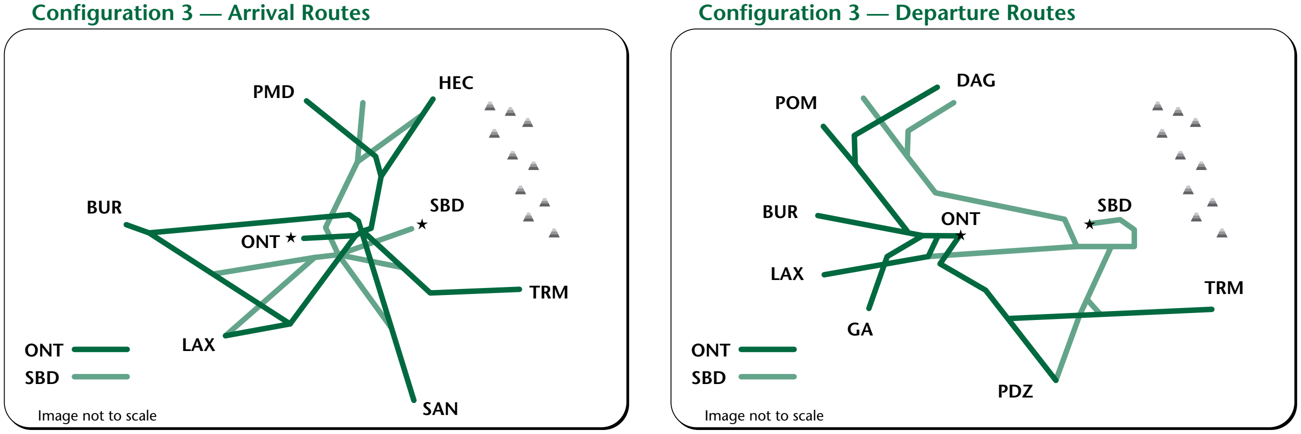


Figure 15. Configuration 4 Arrival and Departure Routes

Configuration 4 — Arrival Routes Configuration 4 — Departure Routes

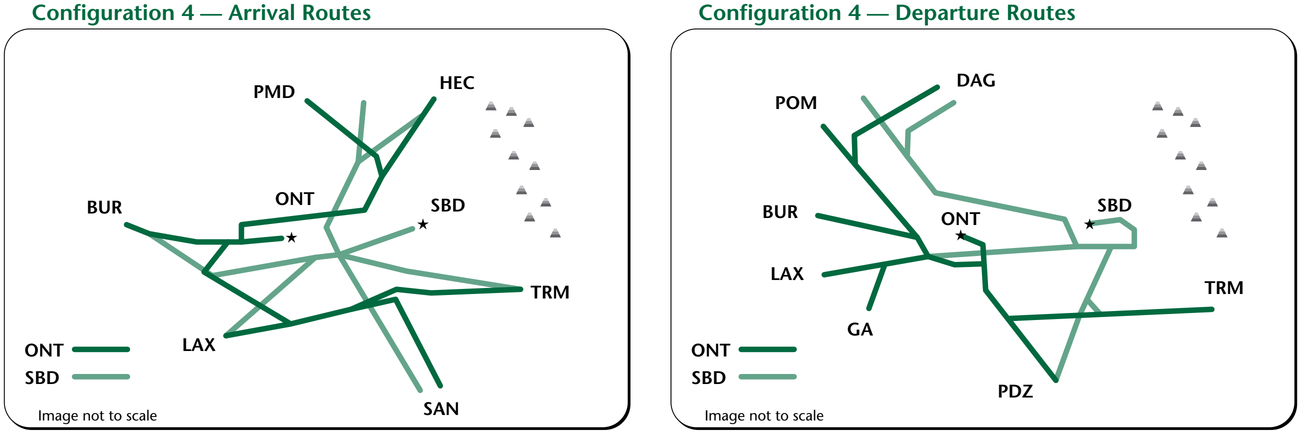
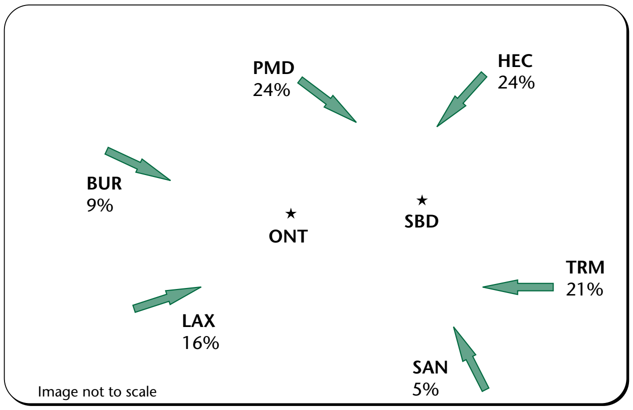


Figure 16. Percent of Aircraft by Fix—Arrivals and Departures

Arrivals



Departures

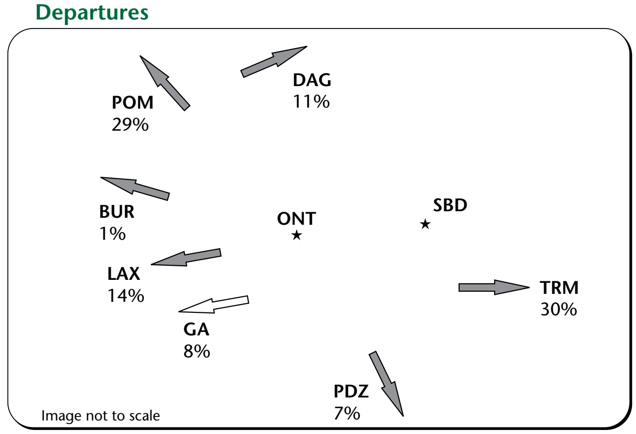


Figure 17. Airfield Demand Levels

Aircraft Operations (Ops) With Aircraft Added from SBD						
	Ops Per Day SBD	Ops Per Year SBD	Ops Per Day ONT	Ops Per Year ONT	Ops Per Day System	Ops Per Year System
Baseline	84	28,560	486	165,240	570	193,800
Future 1	186	63,240	486	165,240	672	228,480
Future 2	280	95,200	486	165,240	766	260,440

Aircraft Operations With Aircraft Moved from ONT to SBD						
	Ops Per Day SBD	Ops Per Year SBD	Ops Per Day ONT	Ops Per Year ONT	Ops Per Day System	Ops Per Year System
Baseline	84	28,560	444	150,960	528	179,520
Future 1	186	63,240	444	150,960	630	214,200
Future 2	280	95,200	444	150,960	724	246,160

Figure 18. Profile of Daily Demand—Hourly Distribution—San Bernardino

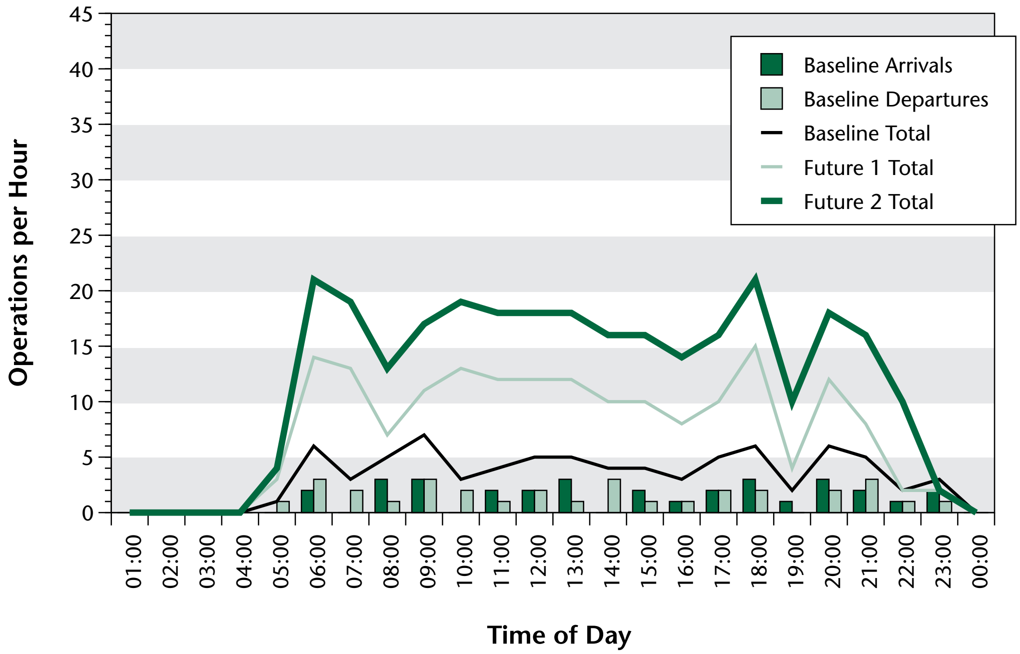


Figure 19. Profile of Daily Demand—Hourly Distribution—Ontario

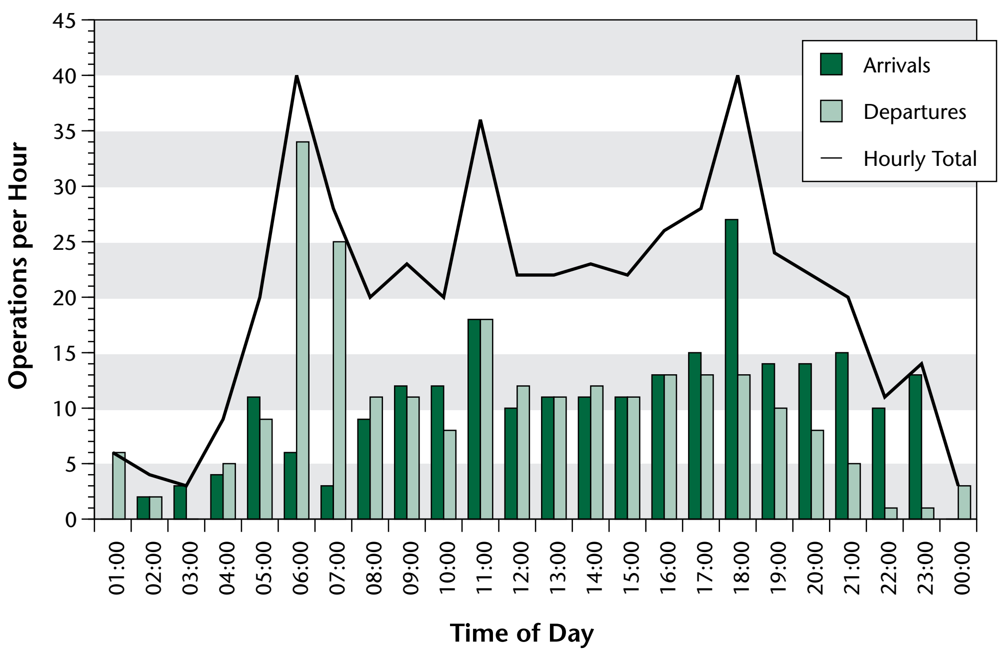


Figure 20. Aircraft Class Description

Aircraft Class	Aircraft Types
Class 1	Heavy aircraft over 300,000 lbs.
Class 2J	Large jet aircraft 12,500 to 300,000 lbs. and small jets
Class 2T	Large turboprop aircraft 12,500 to 300,000 lbs.
Class 3	Twin-engine props 12,500 lbs. or less
Class 4	Single-engine props 12,500 lbs. or less

Figure 21. Aircraft Fleet Mix by Class

Airport	Operations Per Day by Aircraft Classification					Total
	1	2J	2T	3	4	
Ontario	46	258	100	43	39	486
	9%	53%	21%	9%	8%	
San Bernardino	10	44	14	2	14	84
Baseline	12%	52%	17%	2%	17%	
Baseline Total	56	302	114	45	53	570
(SBD+ONT)	10%	53%	20%	8%	9%	
San Bernardino	24	110	22	4	26	186
Future 1	13%	59%	12%	2%	14%	
Future 1 Total	70	368	122	47	65	672
(SBD+ONT)	10%	55%	18%	7%	10%	
San Bernardino	36	168	32	8	36	280
Future 2	13%	60%	11%	3%	13%	
Future 2 Total	82	426	132	51	75	766
(SBD+ONT)	11%	52%	17%	7%	10%	

Figure 22. Aircraft Fleet Mix by Category

Airport	Operations Per Day by Aircraft Category					Total
	Air Carrier	Air Taxi	General Aviation	Cargo	Military	
Ontario	215	131	47	91	2	486
	44%	27%	10%	19%	0%	
San Bernardino	42	14	18	10	0	84
	50%	17%	21%	12%	0%	
Total	257	145	65	101	2	570
	45%	25%	11%	18%	0%	

Figure 23. Aircraft Direct Operating Cost Calculations

Category	Description	Cost Per Minute	Cost Per Hour
AC	Air Carrier operations, mostly Class 2, with some Class 1	$27	$1,620
AT	Air Taxi operations, mostly Class 2 turboprop, with some Class 3 and 4	$8	$480
Cargo	Cargo/Freight operations, mostly Class 1, with some Class 2 and 3	$75	$4,500
GA	General Aviation operations, mostly Class 3 and 4, with some Class 2 jets (2J) and turboprop (2T) aircraft	$1	$60

Appendix C

Computer Model and Methodology

The San Bernardino International Airport Airspace Capacity Design Team studied the effects of initiating commercial air service at San Bernardino International Airport (SBD) on existing air traffic operations in the surrounding airspace, particularly at Ontario International Airport (ONT). The study examined the airspace interactions between arrivals and departures at SBD and the airspace interactions between SBD and ONT. The analysis was performed using computer modeling techniques. A brief description of the model and the methodology employed follows.

Airport and Airspace Simulation Model (SIMMOD)

SIMMOD is a fast-time, event-step model that simulates the real-world process by which aircraft fly through air traffic controlled en route and terminal airspace and arrive and depart at airports. SIMMOD traces the movement of individual aircraft as they travel through the gate, taxiway, runway, and airspace system and detects potential violations of separations and operation procedures. It simulates the air traffic control actions required to resolve potential conflicts to insure that aircraft operate within procedural rules. Aircraft travel time, delay, and traffic statistics are computed and provided as model outputs. The model was calibrated for this study against field data collected at SBD and ONT to ensure it was site specific. Inputs for the simulation model were also derived from empirical field data. The model repeated each experiment 10 times using Monte Carlo sampling techniques to introduce system variability. The results were then averaged to produce output statistics.

Methodology

Model simulations included present and future air traffic control procedures, various airfield improvements, and traffic demands for different times. The projected implementation time for air traffic control procedures and system improvements determined the aircraft separations used for operations under visual flight rules (VFR) and instrument flight rules (IFR).

For the delay analysis, agency specialists developed traffic demands based on the Automated Radar Terminal System (ARTS), historical data, field observations, and various forecasts. Aircraft volume, mix, and peaking characteristics were developed for each demand level (Baseline, Future 1, and Future 2). The estimated annual delays for the proposed improvement options were calculated from the experimental results. These estimates took into account the runway configuration, weather, and demand based on historical data.

Appendix D

List of Abbreviations

AC	Air Carrier
AFB	Air Force Base
ARTS	Automated Radar Terminal System
ASC	Office of System Capacity and Requirements, FAA
AT	Air Taxi
ATC	Air Traffic Control
ATCT	Airport Traffic Control Tower
FAA	Federal Aviation Administration
GA	General Aviation
H2H	Head to Head
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
MAP	Military Airports Program
MI	Miles
NM	Nautical Miles
ONT	Ontario International Airport
OPS	Operations
SBD	San Bernardino International Airport
SIMMOD	Airport and Airspace Simulation Model
TRACON	Terminal Radar Approach Control
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions

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